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CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 14 April 2003 with an application for Letters Patent number 525350 made by Sensortec Limited.

Dated 28 April 2004.

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

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PATENTS FORM NO. 4
Appln Fee: $50.00
James & Wells ref: 121276/16

PATENTS ACT 1953
PROVISIONAL SPECIFICATION

SENSOR APPARATUS FOR EXTRACTION MACHINERY FOR MILKING MAMMALS

WE Sensortec Limited, a New Zealand company of 533 Grey Street, Hamilton, New Zealand

do hereby declare this invention to be described in the following statement:

SENSOR APPARATUS FOR EXTRACTION MACHINERY FOR MILKING MAMMALS

TECHNICAL FIELD

This invention relates to a sensor apparatus to be used with extraction machinery. Preferably the present invention may be adapted to sense or detect the presence of specific components within a fluid extracted by such extraction machinery, where the apparatus is exposed to different streams of extracted fluid to indicate differences in said streams. Reference throughout this specification will also be made to the present invention providing sensor apparatus for milking machinery, where the sensor in question can detect differences between milk supplied from each of a dairy animal's half or quarter udder sections. However, those skilled in the art should appreciate that other applications are also envisioned for the invention and reference to the above only throughout this specification should in no way be seen as limiting.

BACKGROUND ART

Dairy farmers collect milk from herd animals using extraction machinery in the form of milking machines. A dairy farmer will periodically process his or her herd with such machinery to extract milk to be used in food or dairy products.

In the case of dairy cows a set of four teat cups are employed to extract milk simultaneously from the four quarters of the cow's udder. These four teat cups are generally connected together at a single point to a common supply tube or line for milk extracted, with the resulting collection of four cups commonly being referred to as a milking unit. Vacuum or low pressure is applied to these four teat cups simultaneously to deliver the milk extracted into a single collection line, commonly known as the 'long milk tube'.

The four distinct udder quarters and associated teats express milk with various qualities due to microbiological infections which can occur independently in each

udder quarter. Furthermore, medications delivered to the animal to combat such infections can form a contaminant in the milk expressed by each quarter.

As part of quality control regime, existing sensing and analytical equipment can be used to test the milk obtained for such contaminants or the presence of microbiological infections. However, an infection or other contaminants present in one udder quarter only will produce milk which is subsequently diluted by milk obtained from the other, potentially healthy quarters of the udder. This, can for example, make it difficult to detect the start of an infection in one quarter only of the cow's udder.

It is also known to test the foremilk or starting volumes of milk extracted from individual quarters of a dairy animal to obtain an accurate and sensitive sample used to indicate the presence of such contaminants or infections. However, using traditional milking machinery and equipment, there is no facility provided for the extraction, sampling or testing of foremilk prior to the withdrawal of the main volume of milk to be extracted.

One potential mechanism which could be employed to sample or test the milk produced per quarter, would be to place the particular type of sensor or transducer required within the teat cup used for each quarter of the udder. A single sensor can be provided for each teat cup to in turn sample the milk extracted from a single quarter.

However this approach is not necessarily practical as the sensor required would be placed in a relatively hazardous environment. The sensor used would be exposed to moisture and dirt on a frequent basis and would also be in danger of mechanical damage through being kicked or trodden on by the rear hooves of a cow. Furthermore, the provision of multiple sensors would be a relatively expensive mechanism due to the costs of the multiple components used. The provision of

multiple sensors or transducers will also require multiple calibration procedures or runs to be implemented frequently to ensure accurate results may be obtained from each sensor. Data or control signal transmission lines to such sensors would also need to be run through this hazardous environment and again, would be subject to maintenance and damage problems.

An improved sensor apparatus for extraction machinery (and preferably milking machinery) which addressed any or all of the above problems would be of advantage. An apparatus which minimised the number of independent transducers required and which could independently test the milk extracted from each teat and udder section of a dairy animal would be of advantage. Furthermore, a sensor apparatus which maintained or positioned sensor transducers in a relatively secure, clean, dry and/or easily accessible environment would be of advantage.

All references, including any patents or patent applications cited in this specification are hereby incorporated by reference. No admission is made that any reference constitutes prior art. The discussion of the references states what their authors assert, and the applicants reserve the right to challenge the accuracy and pertinency of the cited documents. It will be clearly understood that, although a number of prior art publications are referred to herein, this reference does not constitute an admission that any of these documents form part of the common general knowledge in the art, in New Zealand or in any other country.

It is acknowledged that the term 'comprise' may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this specification, and unless otherwise noted, the term 'comprise' shall have an inclusive meaning - i.e. that it will be taken to mean an inclusion of not only the listed components it directly references, but also other non-specified components or elements. This rationale will also be used when the term 'comprised' or 'comprising' is used in relation to one or more steps in a method or process.

It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

DISCLOSURE OF INVENTION

According to one aspect of the present invention there is provided a controller adapted for use with extraction machinery, said extraction machinery including a plurality of extraction elements which when activated are adapted to deliver an extracted fluid from two or more extraction elements into at least one collection line, wherein the controller is adapted to control the activation of said extraction elements to prevent fluid supplied from all extraction elements entering said at least one collection line at any one time.

According to a further aspect of the present invention there is provided a sensor apparatus adapted to be used with extraction machinery, said extraction machinery including a plurality of extraction elements which, when activated, are adapted to deliver an extracted fluid from two or more extraction elements into at least one collection line,

the sensor apparatus including at least one sensor associated with said at least one collection line, and

at least one controller adapted to control the activation of said extraction elements,

whereby activation of said extraction elements is controlled to prevent said at least one sensor being exposed to extracted fluid supplied from all of said extraction elements at any one time.

The present invention is adapted to provide a sensor apparatus, which preferably is to

be used with, within or be associated with extraction machinery. Such extraction machinery can be employed to extract a particular fluid from any number of different environments.

Furthermore, the present invention also incorporates or encompasses the provision of a controller adapted to control the activation of the extraction elements discussed above. Those skilled in the art should appreciate that such a controller may be provided or implemented irrespective of the sensor apparatus discussed throughout this specification. For example, in one alternative embodiment, the controller employed may be used to apply a pre-stimulation effect to animals from which fluid is to be extracted by the plurality of extraction elements provided. However, reference primarily will be made throughout the specification to the implementation of the present invention as a sensor apparatus but those skilled in the art should appreciate that other applications are also envisioned.

In a preferred embodiment the extraction machinery with which the present invention is to be used may be milking machinery used by dairy farmers. This milking machinery may extract milk from any number of a range of dairy animals such as cows, sheep, goats or any lactating mammal which can be milked cost effectively or efficiently. Milk, being the extracted fluid involved, can be removed from a dairy animal using such milking machinery with the sensor apparatus of the present invention being employed to test, analyse or detect the presence of particular compounds or components within the milk extracted.

Reference throughout this specification will also be made to the present invention being adapted to provide a sensor apparatus to be used with milking machines employed to milk dairy cows. However, those skilled in the art should appreciate that other applications are also envisioned for the present invention and reference to the above only throughout this specification should in no way be seen as limiting.

Furthermore, reference throughout this specification will also be made to a teat cup being employed to extract milk from a single udder quarter. However, those skilled in the art should also appreciate that a single teat cup may extract milk from an udder half section in relation to some types of dairy animal and reference to the term 'quarter' or 'udder quarters' throughout this specification should in no way be seen as limiting. Preferably the present invention may be employed to allow for the controlled application of vacuum or low pressure to individual udder sections of a dairy animal.

Preferably the milking machinery employed includes or incorporates a plurality of extraction elements for each individual cow to be milked. Each of the extraction elements may engage with a teat and associated portion of a cow's udder to extract milk from same.

In a further preferred embodiment, an extraction element may be formed from a teat cup and associated pulsator valve or system. A single cup and pulsator combination can extract milk from a specific quarter of a cow's udder through the use of vacuum.

Reference throughout this specification will also be made to the milking machinery involved having four extraction elements or teat cups and associated pulsators per cow to be milked at any one time. In this way, the present invention may be adapted for use with a standard milking unit used to service a single cow at one time. Again, however those skilled in the art should appreciate that different configurations of milking machinery may also be employed and reference to the above only throughout this specification should in no way be seen as limiting.

Such pulsators and teat cups can be activated in a controlled manner to apply vacuum or pressure below atmosphere pressure to teats of an udder. Furthermore the activation of these extraction elements may preferably be monitored and controlled to ensure efficient and safe milking of a cow, in addition to facilitating the

implementation of the present invention.

Preferably the teat cups provided in such milking machinery may be adapted to deliver the extracted fluid or milk involved into at least one collection line. The combined milk from two or more cups and associated udder halves or quarters of a single animal may be collected through the same collection line. Such a collection line will preferably run to a storage vat which collects and stores milk extracted from an entire dairy herd during one or more milkings.

In a further preferred embodiment, a single collection line may service or collect milk from all four teat cups associated with a single milking unit. This single collection line, which may be defined as a long milk tube, can provide a common linkage from a unified milk collection system to the cups employed with a single milking unit. This long milk tube or single collection line travels at one end from a relatively harsh environment immediately adjacent to the cow's udder, through to cleaner, drier and more accessible regions at which other elements of the milking machinery involved are located.

Reference throughout this specification will be to a single collection line or long milk tube to be adapted to collect milk from all four cups used to milk a single cow. However those skilled in the art should appreciate that a plurality of collection lines with each being adapted to receive milk from two or more extraction elements can also be used in conjunction with the present invention, and reference to the above only throughout this specification should in no way be seen as limiting.

Preferably the sensor apparatus provided in conjunction with the present invention may include at least one sensor which is associated with or located in, or in proximity to at least one collection line. For example, in a preferred embodiment a single sensor may be located in a single collection line or long milk tube which services four teat cups and a single milking unit. The sensor or sensors employed can preferably be

exposed to milk travelling down the single milk collection line to sample, test or analyse same.

Reference throughout this specification will also be made to the present invention providing a single sensor only within the milk collection line or in a position which allows exposure of such a sensor to milk travelling through a single collection line servicing four teat cups. However those skilled in the art should appreciate that other configurations of the present invention are envisioned and reference to the above only throughout this specification should in no way be seen as limiting.

Reference throughout this specification will also be made to a sensor employed being located within a long milk tube or collection line, or potentially forming a serial extension to such a line. This position of a sensor will allow ready access and exposure to milk travelling through such lines.

A sensor as used in conjunction with the present invention may be formed from any of a number of different types of components or apparatus. The sensor or sensors employed may be adapted to detect the presence of contaminants in milk for example, or to measure milk flow rates, volumes, fat, protein or hormone concentrations or any other values or parameters of interest. Those skilled in the art should appreciate that a wide range and number of different types of sensor components and transducers may be used in conjunction with the present invention depending on the particular compound, component or variable to be analysed or detected within the extracted milk.

In a further preferred embodiment, the sensor employed may measure the electrical conductivity of milk travelling through a collection line. Changes in conductivity are known to be associated with the presence of microbiological pathogens within an udder and which indicate one or more udder quarters of a dairy cow are experiencing some form of udder tissue damage.

Reference throughout this specification will also be made to the present invention being implemented through the use of a single electrical conductivity sensor within a long milk tube servicing four separate teat cups and a single milking unit. However, those skilled in the art should appreciate that other configurations of the present invention are envisioned and reference to the above only throughout this specification should in no way be seen as limiting.

In a preferred embodiment the sensor apparatus provided may include at least one controller. A controller may be adapted to control the activation of specific extraction elements or pulsator and cup combinations supplying a single milk collection line at any one time. A controller may preferably be formed from known electrical components such as microprocessors or equivalent analogue circuitry which can be adapted to manage the application of vacuum or low pressure through the teat cups provided.

In a further preferred embodiment a controller may be provided by a pulsator controller normally employed or incorporated into existing standard milking machinery. Such a pulsator controller may be programmed or modified in conjunction with the present invention to vary the times at which specific extraction elements are activated.

In a preferred embodiment the present invention may employ a quad-tube pulsator unit per milking unit employed in the milking machinery involved. A quad-tube pulsator unit may be formed from two twin tube pulsator units per milking unit, or by a customised arrangement of elements which provides four independent pulse tubes in turn to each of the teat cups of a milking unit. The use of a quad-tube pulsator unit ensures that vacuum or low pressure may be applied to each of the teat cups in turn of a milking unit, thereby controlling activation timing of each of these independent extraction elements.

In a preferred embodiment, the controller employed may be programmed, designed or otherwise implemented to control the operation of the quad-tube pulsator unit discussed above. The pulsator controller may emit or issue control signals which operate four separate and independent valves used to apply vacuum or low pressure to each of the teat cups or milking unit in turn.

In a preferred embodiment the controller may be adapted to control the activation of extraction elements so that a sensor within the long milk tube is not exposed to milk supplied from all of the connected extraction elements at any one time. For example, in a preferred embodiment the pulsator controller employed may activate the pulsators of each teat cup in a cyclical, sequential manner. This will prevent specific cups from delivering milk into the long milk tube at the same time as other cups associated with the same udder.

In a further preferred embodiment the controller may be adapted to activate a single extraction element at any one time when a sample of milk to be analysed by the sensor is to be delivered into the long milk tube. This configuration of the controller and its use in conjunction with the present invention ensures that the single sensor within the long milk tube can provide an analysis of milk in transit from a single udder half or quarter only. This allows ailments affecting the particular udder half or quarter in question to be diagnosed in isolation, or for specific contaminants sourced from a single udder half or quarter to be identified without dilution of the milk involved from milk supplied via other udder sections.

Through providing a controlled cyclic activation of suction applied to cups, this can in turn provide an udder stimulation effect prior to a full milking. Milk ejection may be stimulated by the tactile effects of attaching the teat cups and the subsequent physical stimulus provided to the whole udder by pulsating or activating each teat cup in sequence. This pre-stimulation effect may elicit a good milk ejection from the dairy animal involved.

Reference throughout this specification will also be made to the controller employed allowing for the delivery of milk from a single pulsator and milk cup to a sensor for sampling or analysis at any one time. However those skilled in the art should appreciate that other configurations of the present invention are envisioned and reference to the above only throughout this specification should in no way be seen as limiting.

For example, in one alternative embodiment, the milk from two quarters may be extracted and combined within a long milk tube when the sensor employed is activated to sample or analyse said milk. This embodiment would necessarily speed up the sampling and analysis process implemented in conjunction with the present invention, allowing the high flow rate milk extraction required after sampling or analysis to occur earlier.

In a further preferred embodiment, the controlled activation of extraction elements may be adapted to expose the sensor involved to the foremilk obtained from each udder quarter at the start of a milking. Foremilk is known to contain comparatively high concentrations of somatic cells or microbiological organisms, and as such can provide a fluid with relatively high sensitivity to the changes to be detected or measured in conjunction with the present invention.

In such embodiments, the cyclic, controlled activation of milking cups and pulsators can be used to draw foremilk from the quarters of a cow's udder for subsequent analysis by the sensor provided. Once the foremilk required has been extracted and tested or analysed, a normal milking operation may be implemented with milk being drawn from all four quarters of a cow's udder and delivered simultaneously into the long milk tube.

In a further preferred embodiment, a drainage delay period between the activation of specific milking cups and pulsators may also be implemented by the controller. A

delay period may be used to allow the milk supplied from a particular quarter or quarters to be removed from a long milk tube prior to the delivery of further milk from other quarters of a cow's udder. Such a delay period can prevent cross-contamination of milk from various or different quarters, and thereby allow the present invention to provide readings specific to particular quarters more accurately.

In a further preferred embodiment, the order or sequence in which particular cups and pulsators are activated may be randomised. This randomisation element may prevent the same teat and udder quarter being selected repetitively in the same sequence and thereby prevent an off-set or biased results being obtained.

In a preferred embodiment, the controller employed may fully activate one pulsator and associated cup while in turn synchronously triggering suppressed or minimal activation of the other teat cups of the milking unit. This suppressed or minimal activation may provide a massaging or stimulation effect to the other udder quarters involved without necessarily being enough to allow milk withdrawal from each udder quarter. A suppressed pulsation may be applied in such embodiment to provide a heightened pre-stimulation effect to the cow's udder prior to full, high flow rate milk extraction.

In a preferred embodiment, the sensor apparatus provided may include an indicator mechanism which receives the specific reading or output obtained from the sensor or sensors provided. An indicator can, for example, provide a display, alert or alarm to an operator of the milking machinery to indicate that the milk obtained from a particular quarter is abnormal – prior to the bulk of this abnormal milk being delivered into a storage vat for the entire dairy herd involved. Such an indicator may take the form of an audio alarm signal, some form of visual display such as a flashing light.

In a further preferred embodiment, an indicator may provide an output signal or

display which is representative of a ratio of readings or measurements taken and compared with respect to the four udder quarters of the dairy animal involved. Abnormalities or differences in the milk produced by different quarters can be seen easily with such ratio comparisons and therefore will provide a clearer indication that an abnormality has been detected or sensed.

However, in an alternative embodiment different indications or processing of the information or signals obtained from a sensor may be applied. For example, when an animal or herd identification system is linked to the sensor apparatus, a rolling average of measurements made on a specific quarter of the identified animals' udder may be considered. Major or significant changes over time in the measurements obtained with respect to the selected udder can therefore be detected and indicated or displayed.

In a further preferred embodiment the sensor apparatus may also include a trigger mechanism associated with such an indicator. This trigger mechanism may be used to control the operation or activation of further components employed in conjunction with the present invention. For example, in one preferred embodiment a trigger mechanism may be employed to divert or isolate milk determined to be abnormal prior to this milk being delivered to a common collection line or collection vat. If for example, information or readings obtained from the indicator mechanism show that milk is contaminated or has been supplied from an infected udder quarter, such a trigger mechanism may be used to ensure that this milk is isolated from the other 'normal' milk.

The present invention may provide many potential advantages over the prior art.

The present invention may allow for the sampling and investigation of milk from a single or limited numbers of quarters of dairy animal's udder. The sensing apparatus provided can give an indication of problems with specific quarters relatively

accurately, preferably due to the sampling of milk in isolation from such quarters.

The present invention may also be adapted to sample or analyse the foremilk produced from an udder quarter, again to improve the accuracy of results or measurements obtained.

In addition the delayed synchronous activation of extraction elements or milking cups and pulsators can provide a "pre-stimulation" effect to assist in more efficient or faster overall milking of the dairy animal involved. The cyclic extraction of relatively small quantities of milk from each quarter may provide such a pre-stimulation effect.

BRIEF DESCRIPTION OF DRAWINGS

Further aspects of the present invention will become apparent from the following description which is given by way of example only and with reference to the accompanying drawings in which:

Figure 1 illustrates a schematic diagram of a sensor apparatus as configured in accordance with one embodiment of the present invention when used in conjunction with a milking machine for dairy cows;

Figure 2 illustrates a block schematic flowchart diagram of steps executed by the pulsator controller discussed with respect to figure 1, and

Figure 3 illustrates a block schematic flowchart diagram of an alternative pulsator controller programming sequence used in an alternative embodiment available for use with the pulsator controller discussed with respect to figure 1.

Figure 4 illustrates a series of pressure versus time and teat state positions experienced during a single pulsation of a standard milk line pulsator, and

Figure 5 shows a series of plots of pressure versus time for four individual teat cups of a single milk unit or milking unit adapted for use with the present invention.

BEST MODES FOR CARRYING OUT THE INVENTION

Figure 1 illustrates a schematic diagram of a sensor apparatus as configured in accordance with a preferred embodiment when used with dairy cow milking machinery.

The milking machinery shown includes a standard vacuum sub-system and a standard releaser sub-system which interface with modified cluster and pulsation sub-systems.

A standard milking unit or claw, which provides four distinct and separate teat cups, is engaged with a long milk collection tube which subsequently feeds into the releaser sub-system. Also disposed within the collection line is a single sensor, where through operation of the present invention, this sensor (when activated) is exposed to extracted milk supplied from preferably one teat cup only.

The pulsator sub-system includes a quad-tube pulsator which is operated or controlled by a pulsator controller. The quad-tube pulsator provides four separate and independent vacuum lines to each of the four teat cups. This quad-tube pulsator can then in turn apply low pressure or vacuum to each teat cup independently to in turn elicit a milk response from a single teat cup. Milk extracted from a single teat cup can subsequently be analysed in isolation by the sensor provided.

The pulsator controller can also control the operation of the quad-tube pulsators to apply a relatively low vacuum pressure to each teat cup which is not currently being activated for sampling of milk. Application of a low vacuum pressure can provide a pre-stimulation effect to all remaining teat cups, without necessarily allowing milk extraction.

Figure 2 illustrates a block schematic flowchart diagram of steps executed by the pulsator controller discussed with respect to figure 1.

In the embodiment shown, the pulsator controller first waits for the four cups of a single milking unit to be attached to the teats of a cow's udder. When the initial teat positions within their respective teatcups have stabilised, the controller employed then moves to the next operational step shown. At this stage the controller activates the teat cup and pulsator, indicated as cup Q1 allowing the first udder quarter to continue to be milked.

Sensor readings are obtained from the first quarter only through the controller activating only the pulsator and associated teat cup involved. Once the sensor readings required have been obtained, a delay period where no pulsators are activated may be implemented by the controller to allow the long milk tube in which the sensor is located to be emptied clear of any milk supplied from the first quarter.

These two steps are then subsequently repeated for the second (Q2) third (Q3) and fourth (Q4) quarters of the udder currently awaiting milking.

If at any stage the sensor readings obtained from any quarter exceed a predetermined threshold value indicating the likely presence of a contaminant or an infection, an alarm condition is triggered. This alarm condition can for example provide a visual indicator of a problem to the operator of the milking machinery involved, or alternatively trigger the activation of a diversion mechanism which isolates any milk obtained from the current animal being milked from a common collection system and vat.

Figure 3 illustrates a block schematic flowchart diagram of an alternative pulsator controller programming sequence as discussed with respect to figure 2.

In the embodiment shown with respect to figure 3, a compromise is made between

the speed at which samples are obtained from quarters and the accuracy of the measurements made. In the scheme discussed with respect to figure 3, the pulsator controller employed activates the pulsators associated with both the first and the second quarters of the udder synchronously. This results in milk withdrawal from both quarters at once which is supplied to the long milk tube and associated sensor.

A similar process is then completed after the long milk tube has been allowed to drain to obtain combined milk from both the third and fourth quarters of the udder.

This compromise programming will provide combined or approximate results from a pair of udder quarters at once, but will speed up the entire sample taking and processing times involved.

Figure 4 illustrates a series of pressure versus time and teat state positions experienced during a single pulsation of a standard milk line pulsator.

As can be seen from the diagram shown with respect to figure 4, the initial position of the teat shown is in the opening phase where vacuum is increasing and milk starts to flow from the teat in the time region F indicated. Conversely when the vacuum begins to drop substantially in region S, the teat cup liner will begin to close and milk flow will be stopped by the closing liner.

As can be seen from figure 4, an applied vacuum below the threshold level indicated at F will supply a physical stimulation effect to the teat but will not necessarily elicit milk flow. Conversely a vacuum applied above this region or level will elicit a milk flow until the liner is closed again.

Figure 5 shows a series of plots of pressure versus time for four individual teat cups of a single milk unit or milking unit adapted for use with the present invention.

As can be seen from the plots shown with respect to figure 5, the vacuum or low pressure applied to the pulsation chambers of each teat cup Q1 through Q4 varies

over time. Initially, a high vacuum pressure is applied to allow the teats to stabilise within their respective teatcups. Next the vacuum applied to the pulsation chambers of teatcups Q2 through Q4 is dropped to below a threshold pressure level which will not elicit milk flow from each teat but which will supply a pre-stimulation effect to same. At the same time a high vacuum is applied to the pulsation chamber of teatcup Q1 to elicit a milk flow for sampling and analysis.

After teat Q1 has been sampled the same approach is taken with respect to teat Q2, and the same pre-stimulation low vacuum is now applied to teat Q1, Q3 and Q4 consecutively without eliciting a milk ejection.

In this manner, all four teats can be pre-stimulated prior to extraction of substantial volumes of milk, while a sample of milk may be extracted from each teat independently for sampling analysis prior to a full milking. As can be seen from figure 5 once a milk sample is obtained from all four teats, a normal vacuum can then be applied to the pulsation chambers of each of the teatcups to elicit a full simultaneous milking.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof.

SENSORTEC LIMITED

by its Attorneys

JAMES & WELLS

FIGURE 1

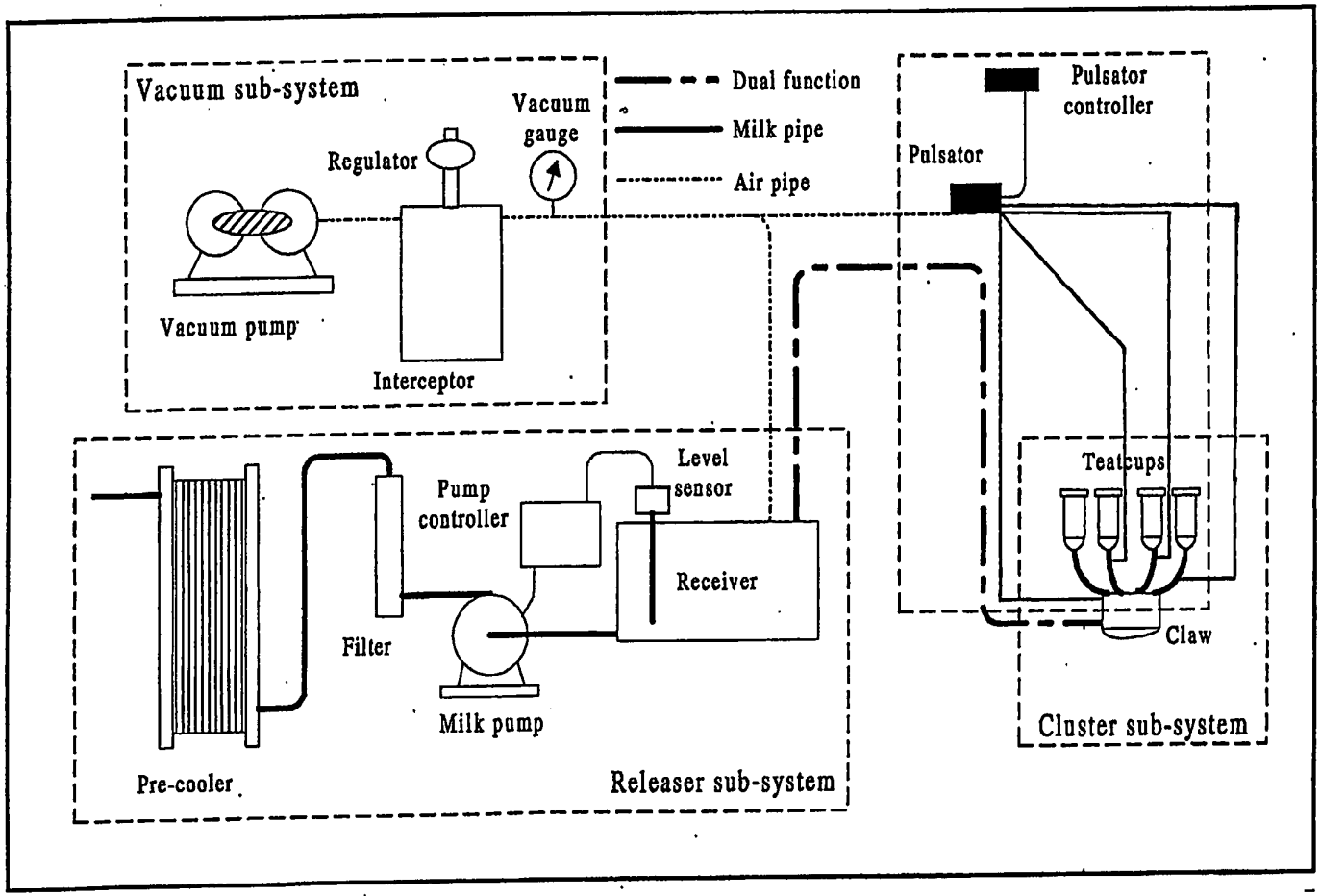

Vacuum sub-system
Vacuum gauge
Regulator
Vacuum pump
Interceptor
Dual function
Milk pipe
Air pipe
Pulsator controller
Pulsator
Level sensor
Pump controller
Receiver
Filter
Milk pump
Pre-cooler
Releaser sub-system
Teatcups
Claw
Cluster sub-system

FIGURE 2

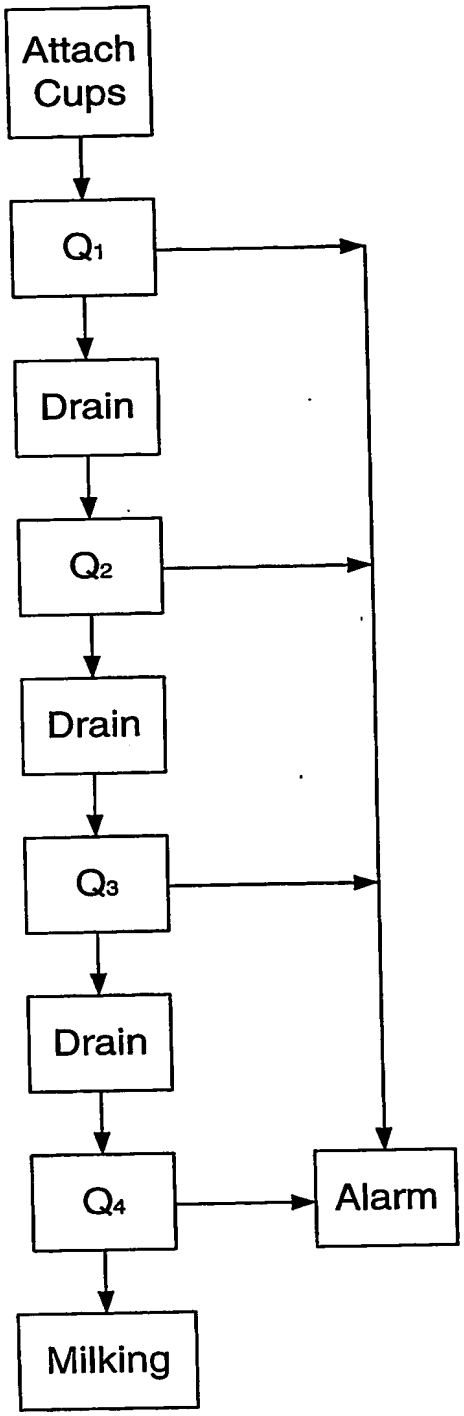


FIGURE 3

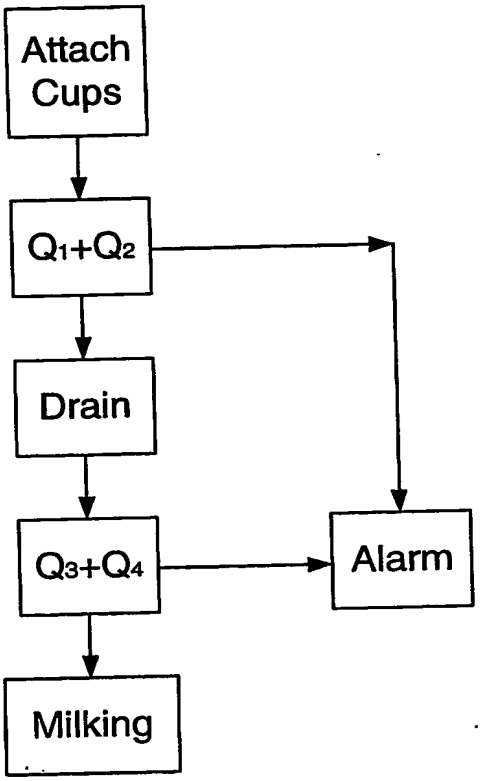
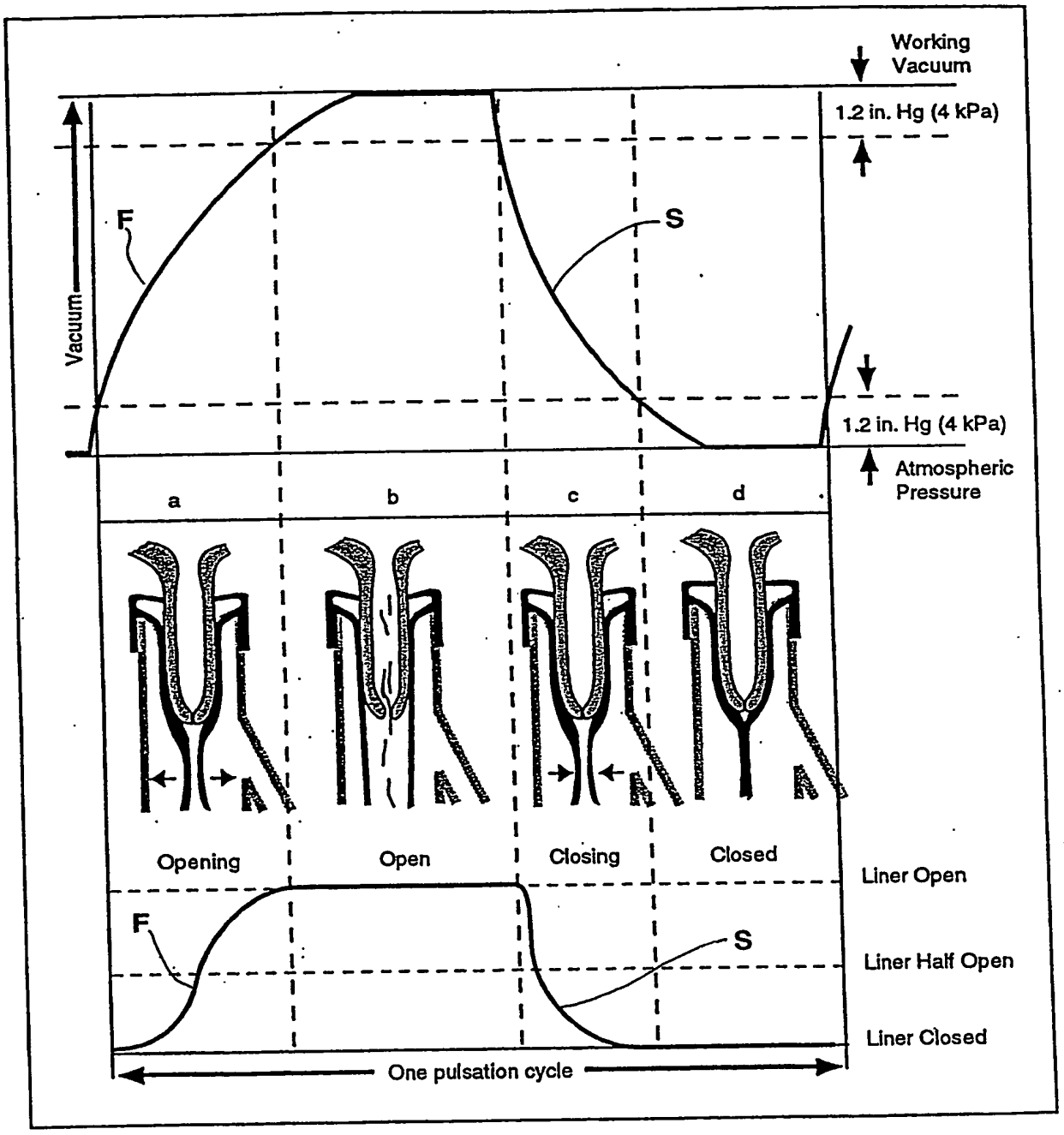


FIGURE 4


Working Vacuum
1.2 in. Hg (4 kPa)
F
S
Vacuum
1.2 in. Hg (4 kPa)
Atmospheric Pressure
a
b
c
d
Opening
Open
Closing
Closed
Liner Open
F
S
Liner Half Open
Liner Closed
One pulsation cycle

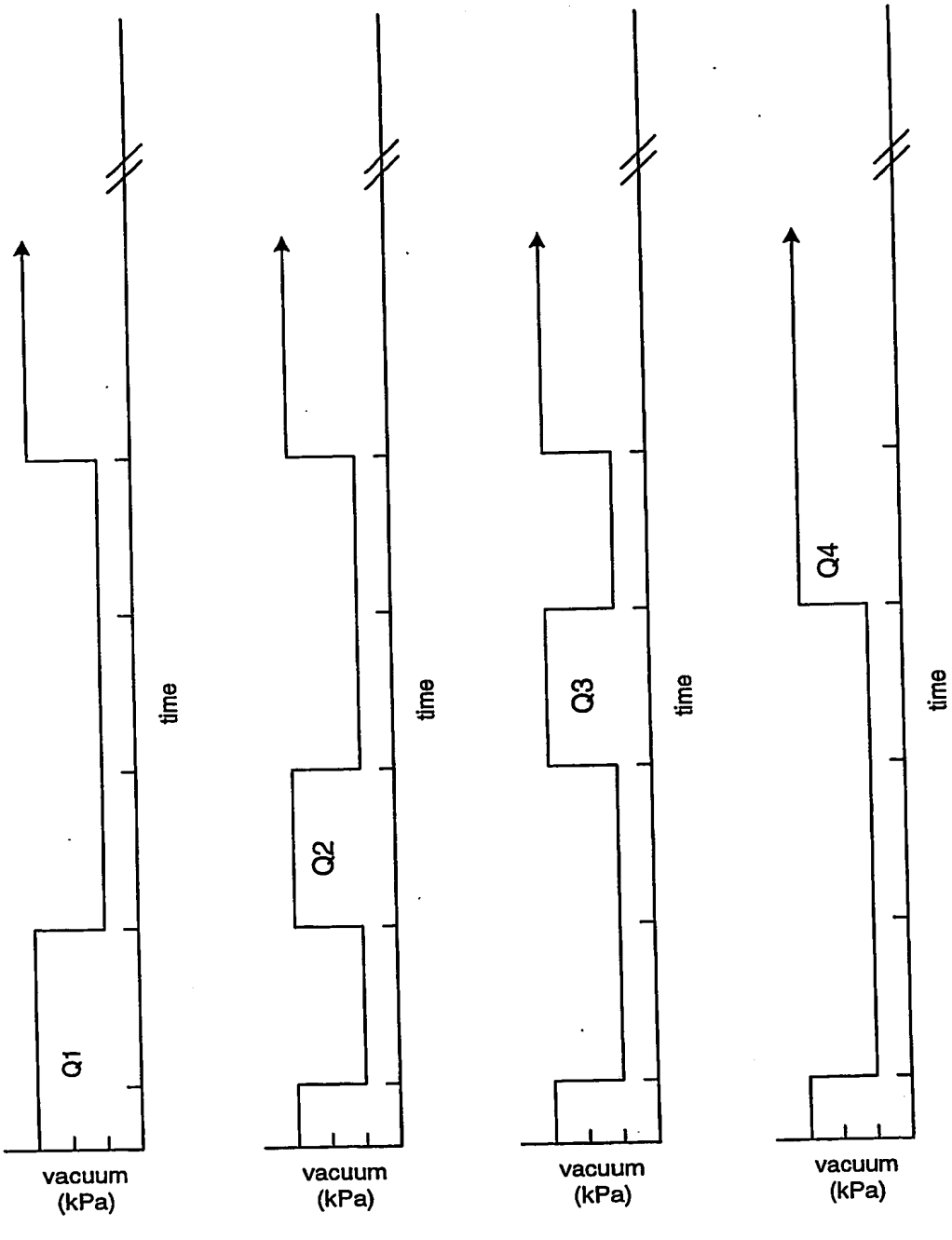

Q1
vacuum (kPa)
time
Q2
vacuum (kPa)
time
Q3
vacuum (kPa)
time
Q4
vacuum (kPa)
time

FIGURE 5